Section 230
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GENERAL PRINCIPLES OF SERVING AREA VALUE ENGINEERING

CONTENTS

1. GENERAL

1.01 This section provides REA borrowers, consulting engineers, contractors, equipment manufacturers and other interested parties with new recommendations using the Serving Area Value Engineering (SAVE) concept for the design of rural telephone plant. Increased emphasis is placed on the use of 24 gauge cable and pair gain devices (distributed and grouped station carrier, PCM carrier and electronic concentrators) to reduce the cost of systems serving rural subscribers. Companion sections TE & CM 231 and 232, "Design Techniques for Serving Area Value Engineering", and "Transmission Design Considerations for Serving Area Value Engineering", provide information on the design techniques and the selection and use of pair gain devices. TE & CM Sections 629 and 648, "Cable Plant Layout for SAVE", and "Serving Area Value Engineering (Physical Plant)" provide information on plant design aspects. All of the above material will need to be considered in applying the SAVE concept to specific systems.

1.02 The basic building block of the new method is a load coil bounded area which is called a "Design Area", (DA). Five year estimates of subscribers within the design areas and estimated growth rate become the basis for the design. One or more design areas can be combined to become a serving area. Subscribers within the resulting serving area may be connected to distribution cable pairs which are cross-connected to feeder pairs at a control point called the Serving Area Interface (SAI). Figure 1 illustrates a design area.

1.03 The objective of the new design method is to construct a system that can easily and economically be operated and expanded for the next 10 to 15 years, at a cost that will not penalize the existing subscribers who are presumed to be subscribers for the entire period.

1.04 The anticipated advantages of the SAVE method of designing and constructing telephone systems are:

(a) Provides flexibility in the use of feeder circuits (electronically derived or physical) to meet forecasted or unforecasted service demands.

(b) Provides for growth in an orderly manner without extensive changes in cable plant. A tight feeder complement that is readily expansible and a detailed circuit count of distribution pairs, generally usable in several design areas.

(c) Provides for the orderly and economical introduction of pair gain devices over preassigned cable pairs to minimize premature investment in feeder circuits. This is especially valuable in areas with changing growth patterns.

(d) Provides for improved plant layout and facilities to reduce plant administration, operation and maintenance costs. It is expected to result in reduced costs for plant assignments, subscriber connections and trouble clearing during the service life of the system.

(e) Provides for an economic balance in the use of copper and electronics.

(f) Provides for reduced housekeeping problems in pedestals and cross-connect points, especially where intense subscriber rearrangements occur. In addition to giving more efficient feeder utilization, Serving Area Interfaces (SAI's) provide test points for acceptance tests and trouble clearing.

(g) Provides flexibility to meet demands for special services.

(h) Provides uniform transmission treatment for distribution circuits connecting to physical, carrier or concentrator feeder circuits.

(i) Provides for a worksheet that makes the design and the review of the design advantageous for exchanges where it is not practical to put the outside plant design on a single map.

(j) Provides the essential elements to use the computer to assist in the design of the system, maintenance of records and operation of the system.

1.05 There can be a substantial annual cost penalty if the lowest installed first cost system is always selected. The recommended criteria for the best design is consideration of meeting service demands as they occur, flexibility to achieve efficiency in plant utilization, economical and efficient plant reinforcement, deferment of investment in idle plant through planned physical rearrangements and the use and reuse of movable electronic plant. Thus SAVE is concerned to a much greater extent with operating system facts of life than previous REA design recommendations. Likewise, judgment should be used to temper broad gauge Present Worth of Annual Charge (PWAC) studies in areas of rapid growth and station movements to avoid inefficient reinforcement and the effect of too frequent rearrangement on the subscribers.

1.06 Prior to the preparation of the system design there will generally have been completed a long range plan which considers subscriber growth and services, elimination of small central offices, introduction of common control switchboards, interoffice trunking, etc. Some systems will find these criteria of value in developing and updating their long range plan.

1.07 Systems with cable records and subscriber data in computer format will find this new outside plant design method readily adaptable to computer programming. The most laborious and time consuming part of outside plant design is transferring up to date existing plant and subscriber data onto maps or worksheets.

1.08 Before attempting to undertake the development of an outside plant system design, the engineer should be thoroughly familiar with the advantages and limitations of electronic and other equipments which should be considered.

1.09 The engineer will find helpful application and design information in the latest editions of the following REA TE&CM Sections:

TE&CM Section & Addenda	Title
116	Plant Engineering and Record System
203	Existing Plant Considerations for a Telephone System
204	Telephone System Design
206	Preparation of an Area Coverage Survey
210	Telephone System Design Criteria - Engineering Time Periods
231	Design Techniques for Serving Area Value Engineering
232	Transmission Design Considerations for Serving Area Value Engineering
406	Transmission Facility Data
424	Design of Two-Wire Subscriber Loop Plant and PABX Trunk Plant
629	Cable Plant Layout for SAVE
648	Serving Area Value Engineering (Physical Plant)
911	Station Carrier Application
930	Use of Point-to-Point Radio (Microwave) in Telephony
950	PCM Carrier for Rural Telephone Systems

1.10 The guidelines presented in the SAVE plan consider many factors and offer a wide latitude for engineering judgment in designing exchange plant. The SAVE design technique should be used in all outside plant designs to provide an orderly procedure to insure proper consideration of various ways of providing subscriber loops which will be the most economical method over a long period of time. The use of the SAVE design technique does not require the installation of SAI housings and components. Any designated interface points may be hard-wired in standard pedestals and replaced by SAI type housings as required.

2. SERVING AREA DESIGN

2.01 One of the modules (components of the design) is a load coil bounded long range design area (Figure 1). Rarely will it exceed the 300 subscribers that can be practically served from a Serving Area Interface (SAI) for this size area.

2.02 Generally, load coil bounded design areas are combined into an enlarged serving area to increase the efficiency of the feeder circuits between the feeder inter-connect pairs at the SAI and the central office. Subscribers within a serving area are connected by distribution cable pairs and at the SAI are interconnected to the feeder pairs by jumpers using terminal blocks or splicing connectors.

2.03 The feeder circuits may be loaded or non-loaded voice frequency cable pairs, carrier (over wire or radio) or concentrator trunk circuits within 8 or 10 miles of the central office. However, the trend is toward electronically derived circuits in the five to ten mile range.

2.04 If pair gain equipment is subsequently added at an SAI (or at a later date a new SAI is created) distribution pairs would then be connected to feeders derived by carrier channels. To provide for this flexibility with a minimum of engineering design later on, it is desirable to establish SAI's at load points if <u>conveniently possible</u>. To do otherwise will require observance of some transmission limitations discussed in TE & CM 232, Paragraph 2. To reduce electronic housing costs and to improve operating efficiency, it is desirable to locate electronic equipment at load coil locations.

2.05 With average rural subscriber density it will generally be found desirable to combine two to five or more load coil bounded design areas in tandem. Please refer to Figure 2. However, in very high density areas it may be desirable to sub-divide the load coil bounded design area into two or more 300 to 600 subscriber serving areas.

2.06 Since standard PIC cable color code is based on groups of 25 pairs and subgroups of 5 pairs it is desirable to assign distribution and feeder physical pairs to the serving areas in multiples of 5 pair for record keeping and other operating and construction advantages.

2.07 In the SAVE design, the <u>high</u> count pairs in a new combination feeder and distribution cable are assigned as distribution pairs. The <u>mid-count</u> pairs should be assigned as loaded feeder circuits. It would be desirable to assign the low count pairs to carrier, which would be unloaded pairs. This procedure is usually feasible in applying station carrier equipment which are two wire systems operating at low frequencies. If four wire PCM carrier is applied, the application rules of TE & CM 950 apply which may mitigate against the low count pair assignments.

2.071 The purpose of the recommended assignments is to simplify the administration of assignments over the operating life of the cable plant. In a typical case, as growth occurs, the number of VF distribution pairs will need to increase. The increased number of feeder pairs required will be increased primarily through application of

electronic derived pair gain devices. As the feeder circuits reserved for carrier are used up, the number of loaded feeder pairs will be reduced and the carrier pairs will be further increased. The basic assignment arrangement will then permit feeder circuit growth from low count up and distribution circuits from high count down. This simplifies administration and cross connection. Refer to TE & CM Section 629 for refinements in cable pair assignments.

2.08 To provide for the flexibility discussed in 2.07, feeder cable pairs reserved for carrier should be available at every SAI on each cable route.

2.09 The serving area interface (SAI) where distribution pairs and feeder circuits are to be cross-connected is a logical place to be able to introduce pair gain devices on the feeder circuits. Carrier or concentrators may be used initially. With a properly designed system, this will generally be the lowest annual cost method of reinforcement later on.

2.10 To provide flexibility, non-loaded pairs reserved for carrier should be available at every SAI. The design technique calls for a minimum of 10 percent of the pairs (up to 50 pairs) in cables being used or reserved for carrier. Some of these spare pairs can be designated as "test pairs" for the operation and maintenance of the system.

3. SAVE DESIGN STRATEGY

3.01 In implementing the serving area concepts discussed in Paragraph 2.0 and to obtain optimum utilization of the economics and flexibility of the various plant items required to realize the design objectives, there are basic precepts that need to be kept in mind as the design procedure is implemented. Some of the more important of these are outlined in the paragraphs that follow.

3.02 When reinforcing cables are required, use 24 gauge extensively. In most rural designs, when augmented with carrier, it results in the lowest annual cost per circuit even on subscriber loops up to 20 miles in length.

3.03 Consider new 26 gauge cable whenever a separate feeder (no access by station installers) cable of 200 pair or more can be justified. Consider new 22 gauge cables only when subscriber loops extend more than 15 miles from the central office. Consider new 19 gauge cables only when loops extend 25 or more miles from the central office.

3.031 The installed cost per pair of cables smaller than 25 pairs is relatively high. As a result, small size cables will be installed with a low fill. Accordingly, deferring a small reinforcing cable through use of carrier circuits until demand grows to require a larger reinforcing cable can be good engineering design even though, initially, the use of carrier may not prove to be economical. The movability and high salvage value of the reusable electronic equipment is a major factor in this design discussion.

3.032 Near and beyond the carrier breakeven point, consider 22 gauge for small cables mainly for distribution. This will aid in the use of grouped station carrier allowing it to reach two design sections but not increase costs unduly.

3.04 Before the final recommendation of a design is made, examine routes with reinforcing cables of 200 pair and larger for opportunities to reroute physical feeder pairs. Transferring 50 feeder pairs or more to an essentially paralleling route may significantly reduce the cost per pair along the alternative route.

3.05 Carrier and concentrators are both pair gain devices. They have several roles to play in the new design concept. (1) Much of the investment can be deferred when pair gain facilities are planned to serve subscribers where buildings are not under construction. (2) Pair gain can be used to defer reinforcement with small size cables. This is especially important with buried cable because of increased placement costs on routes with existing buried cables. Adding aerial cables can overload existing poles which can be disastrous in areas subject to storms. (3) Pair gain may frequently be used economically to defer cable reinforcement until a new cable, with as many pairs as already in place, can be justified.

3.06 To reduce operating costs, concentrators, carrier terminals, and carrier repeaters should be planned to share an electronic housing adjacent to the SAI. When it is economical to defer a separate electronic housing, the SAI should be used to house electronic equipment.

3.07 Carrier and concentrators are planned at load coil locations to improve feeder flexibility (physical to concentrator or carrier) and to facilitate the transfer of loaded and non-loaded cable pairs on the field side of the cross-connect point from physical feeders to distribution pairs.

3.08 To improve operating efficiency, including ease in trouble-shooting as well as maintaining high carrier system fills, locate station carrier channels in groups to the maximum practicable extent.

3.09 Pair gain devices (even the one channel system) may be more costly on an annual charge basis when installed close to the central office but they may be advantageous to defer cable reinforcements.

They should be recognized as removable plant with a high salvage value because they are reusable for a similar purpose or in a more permanent location at a greater distance from the central office.

3.10 When initially introduced, the SAVE concept tries to use multiples of 25 pair cables. Once established, it tries to use multiples of 100 pairs for reinforcing cables. There is no standardization in the cable makeup in unscreened cables for initial or future PCM capability. In contract construction, there is generally no way to select non-adjacent binder groups for increased crosstalk loss or prepare splicing instructions until the cable is delivered to the project. Placing repeaters at 4.5 KF spacing increases the number of PCM systems possible in the non-screened binder groups. Nevertheless, pair selection and crosstalk tests may be required. Compartment type cable should be specified if carrier use is imminent.

3.11 It is generally desirable to treat long runs of new cables of 18 pair or less as part of an enlarged serving area. The 18 pair (or less) cable pairs should be treated as distribution pairs to be cross-connected (or spliced) to feeder pairs at the SAI. Future serving area interfaces can be hard-wired initially. Subscribers are assigned in anticipation of providing future relief with pair gain devices.

3.12 Retainable cable plant which passes through distribution housings and ready access enclosures usually should have existing pairs converted to distribution use. It is not always wise to select existing coarse gauge cable pairs for carrier use. When a filled reinforcing cable is to be installed, it is generally desirable to run it into buried plant housings only at SAI's. The potential savings in a reduced number of carrier repeaters, by using existing coarse gauge cable pairs rather than a new filled 24 gauge cable, should be weighed against (1) the desirability of relying less on the transmission stability of air core cable for long feeder circuits; (2) additional complications in the conversion such as load coil removals from working circuits and frequency response tests to determine suitability of existing plant for carrier; (3) the increased exposure of reinforcing cable and the increased number of shield openings due to unnecessary appearances in distribution housings; (4) the advantage of the low resistance pairs for VF distribution between the subscriber and grouped carrier terminals.

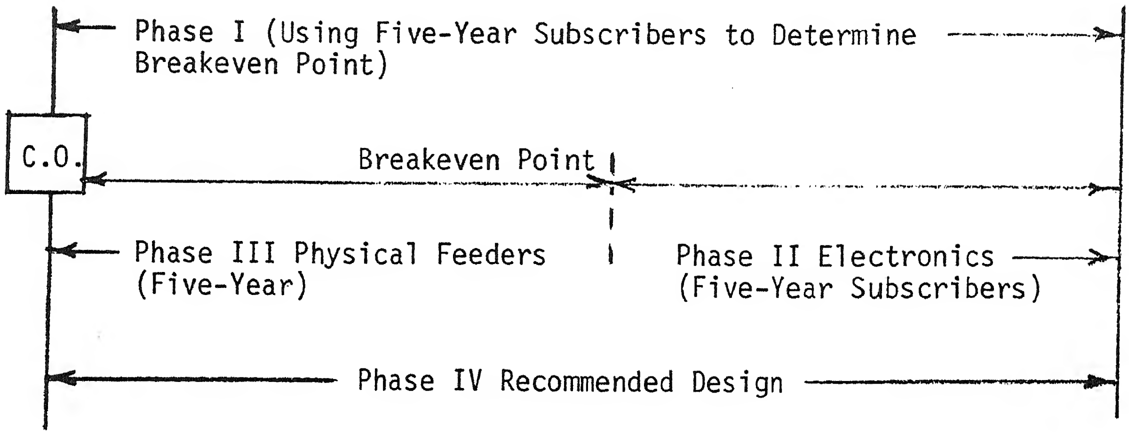
3.13 Try to avoid establishing an SAI with as few as five physical feeder pairs unless a concentrator with physical trunks is justified initially or it is logical for the next reinforcement at the SAI to be made with carrier or a concentrator.

3.14 Broad gauge cost studies should generally be made using the present worth of annual charge (PWAC) method. Sinking fund depreciation rates should be used as an offset to the high cost of money.

4. SAVE TECHNIQUE FOR DESIGNING THE OUTSIDE PLANT

4.01 Described briefly below is a method intended (1) to insure proper consideration of various means of providing subscriber loops, and (2) to reduce premature investment in plant.

4.02 Four phases of making the design are suggested.



4.03 Phase I begins with data concerning reusable existing plant, five-year (existing plus potential) subscribers and probable new cable routings. Tentative reinforcing cables required for five-year subscribers are determined throughout the exchange. The broad gauge cost per physical feeder and each type of carrier between the central office and each load coil location is determined. The load coil locations where electronic feeders are equal to or less costly (on an annual charge basis) than physical feeders are called the breakeven points. Only the five-year subscribers are put in the DA (design area) blocks, but the existing subscribers will show the growth rate in the area involved.

4.04 Phase II begins with the results of Phase I. Five-year subscribers beyond the breakeven points are designed to be served by electronic feeders. Specific locations for concentrators and/or subscriber carrier and cross-connect blocks are selected and the number of physical or electronic feeders is determined. The locations of SAI's establish serving area boundaries which may be adjusted in Phase IV.

4.05 Phase III begins with the results of Phase I and Phase II. Five-year subscribers beyond the breakeven point are to be served by carrier and/or concentrators. Therefore, a reduced number of cable pairs between the breakeven point and the central office than indicated in Phase I may be required to serve them. New reinforcing cable sizes generally result. Specific locations for Serving Area

Interfaces are then selected and the number of physical and electronic feeders is determined.

4.06 In Phase IV the engineer further evaluates the results of Phase II and III. The final review should consider the SAVE Design Strategy described in Paragraph 3 and the advantages and limitations of the facilities to be incorporated into the system.

4.07 In making final decisions on the type of carrier to be selected, the engineer should consider (1) the number of electronic equipment housings required; (2) the number of intermediate power supplies required; (3) the ease of meeting unanticipated growth; and (4) the operating advantages.

4.08 In making a final decision on the number and assignment of physical feeder pairs consider that (1) there should be adequate spare carrier pairs; (2) carrier pairs in cables of 25 pair and above should be capable of PCM operation; (3) physical pairs beyond the 5th or 6th (D-66) load coil can be economically reinforced by electronics, on a temporary basis; (4) spare pairs close to the central office should remain non-loaded. (They are then available for carrier, non-loaded feeders or distribution pairs. Load coils can always be added); (5) reinforcing cable pair size changes should only be made at existing or future SAI's or major road intersections.

4.09 A step-by-step procedure which follows the method described above, and is readily adaptable to computer programming, is given in TE & CM 231.

5. MODIFICATIONS REQUIRED FOR 2 (OR 4) PARTY DESIGNS

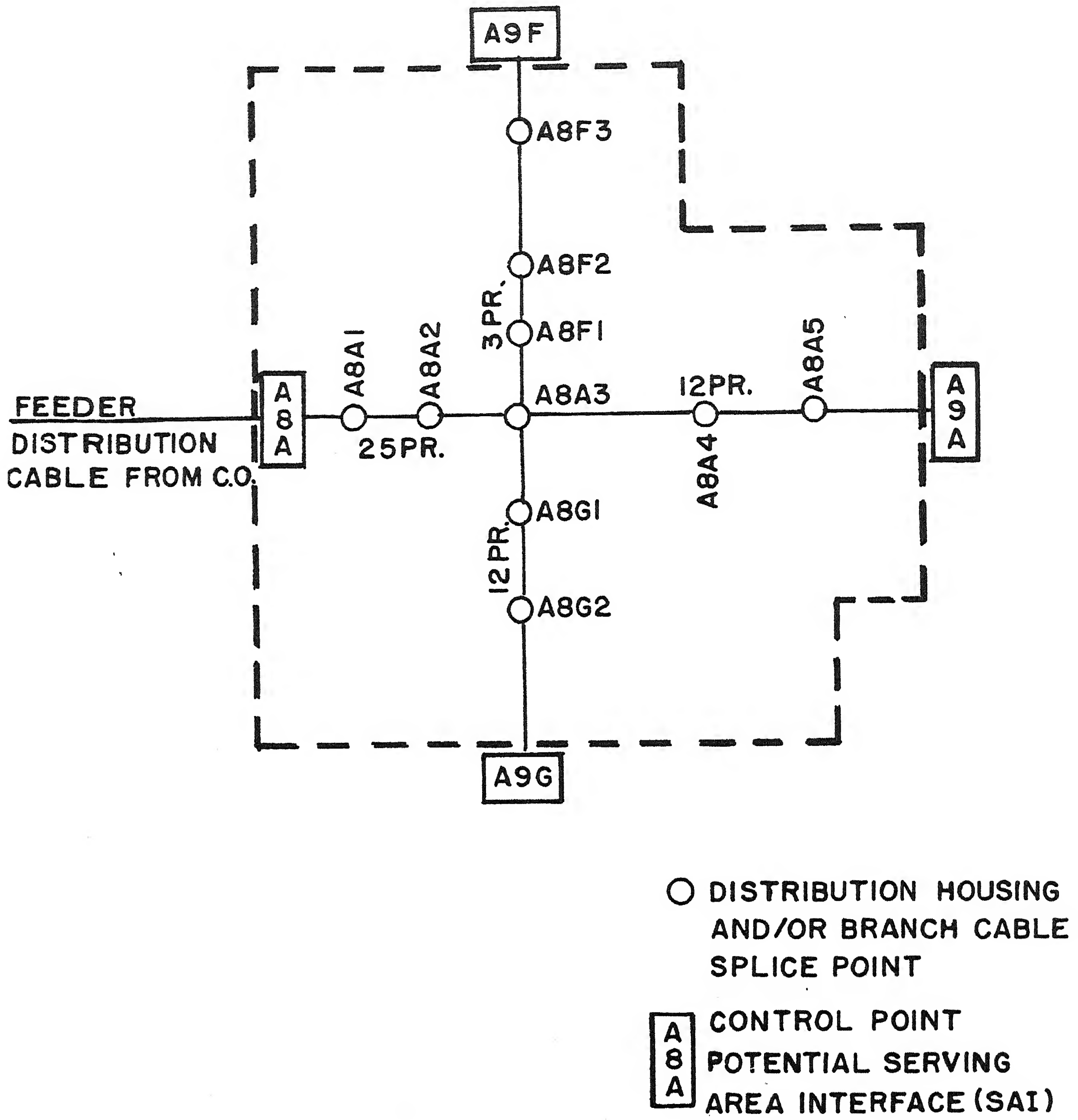
5.01 To use for 2 or 4 party designs, convert the 2 and 4 party subscribers to circuits and show circuits in the five-year subscriber design area blocks. Provide distribution pairs for 1-party conversion if new plant is to be installed. Proceed as if it were 1-party design.

5.02 Normally it is expected that one-party service is a future consideration. If this is so, small cables designed mainly for distribution use should provide generous pairs to make the future one-party conversion less costly. Main routes where a future addition will be needed, but delayed now due to costs should indicate how the future circuits might best be provided, such as with carrier or cable.

5.03 Party line subscriber carrier should be used to extend life of existing outside plant. The use of party line carrier between the breakeven point and the central office can frequently be justified in such designs. The useful life of the carrier can be greatly extended by transferring the units to beyond the breakeven point when it becomes economical to install a reinforcing cable on the central office side of the breakeven point during the upgrade to one-party.

5.04 When small reinforcing cables are installed, mainly for distribution pairs for future one-party service, connect four-party subscribers to a control point on the same party line to the same distribution pair to avoid bridge tap transmission problems. A control point is a pedestal close to the party line subscribers within the area of the SAI.

FIGURE 1 - DESIGN AREA (LOAD COIL LIMITED)



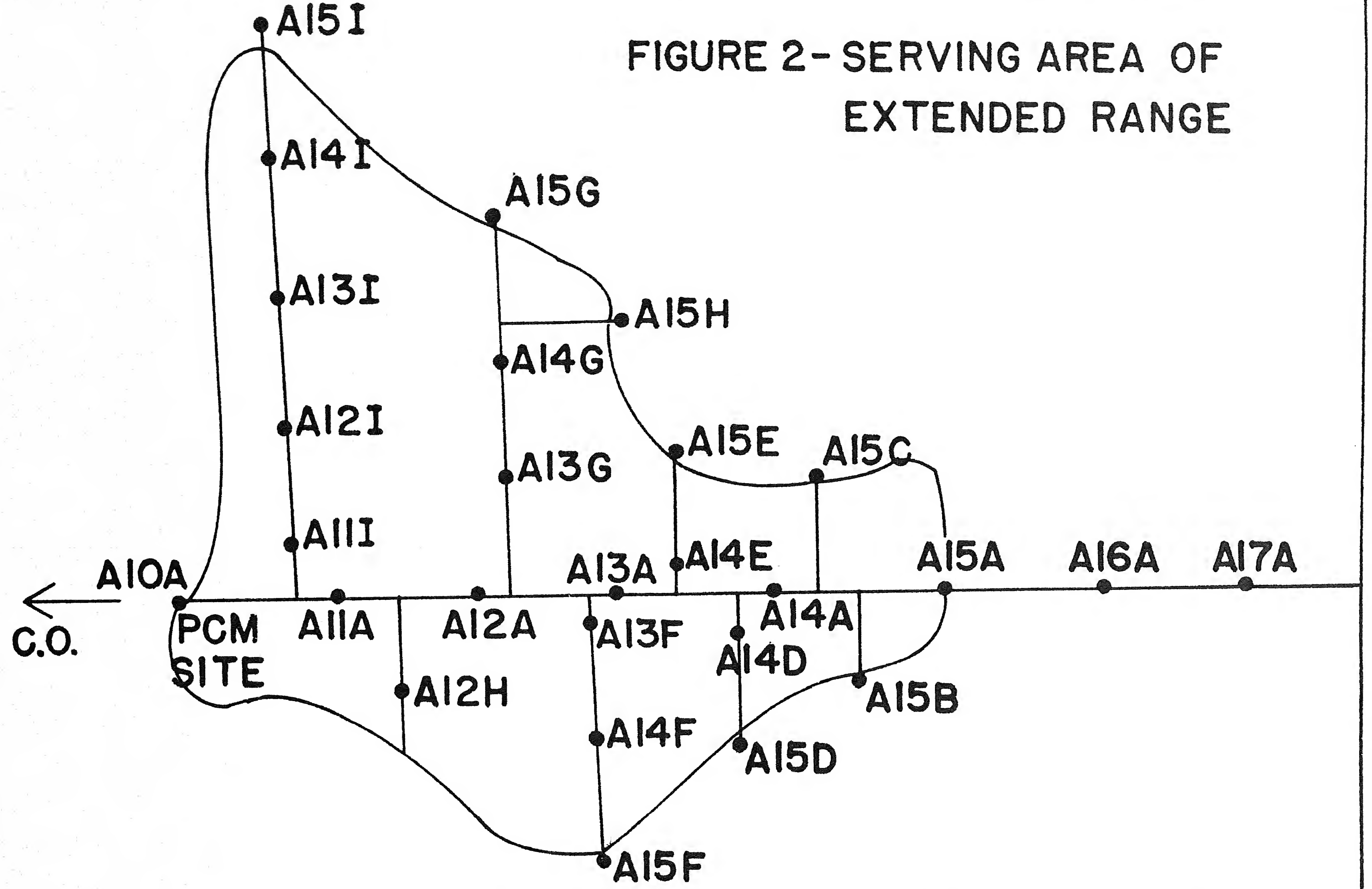


FIGURE 2- SERVING AREA OF EXTENDED RANGE

24GA SERVING AREA-FEEDERS PROVIDED BY PCM CARRIER
22GA EXTENDS RANGE TO 8MILES (TRANSMISSION LIMITS)